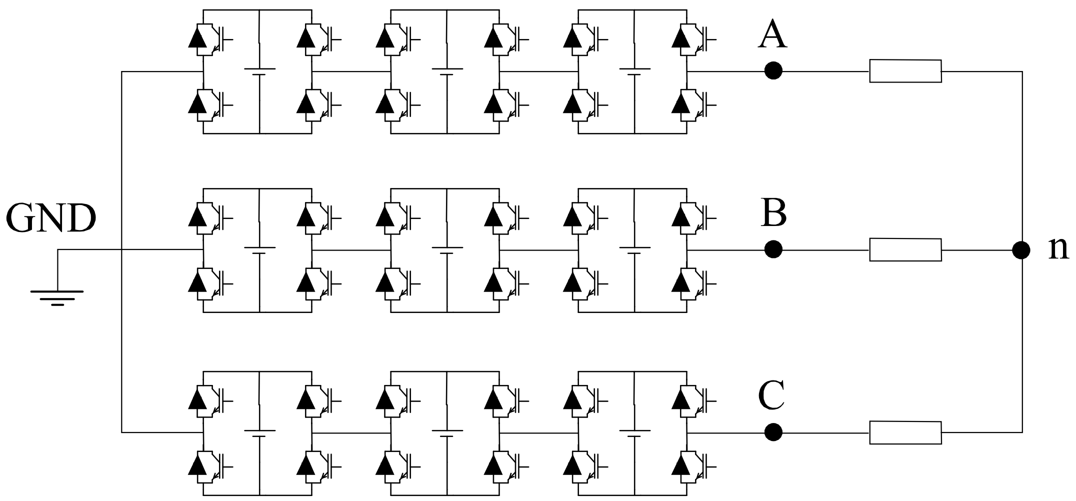
Demonstration 9

Tutorial exercises

Problem 1

Consider the cascaded three phase full bridge inverter with a purely resistive load below. Each H-bridge is connected to an ideal DC-source, V_d. The switching angle is 10°, 20° and 50° respectively.

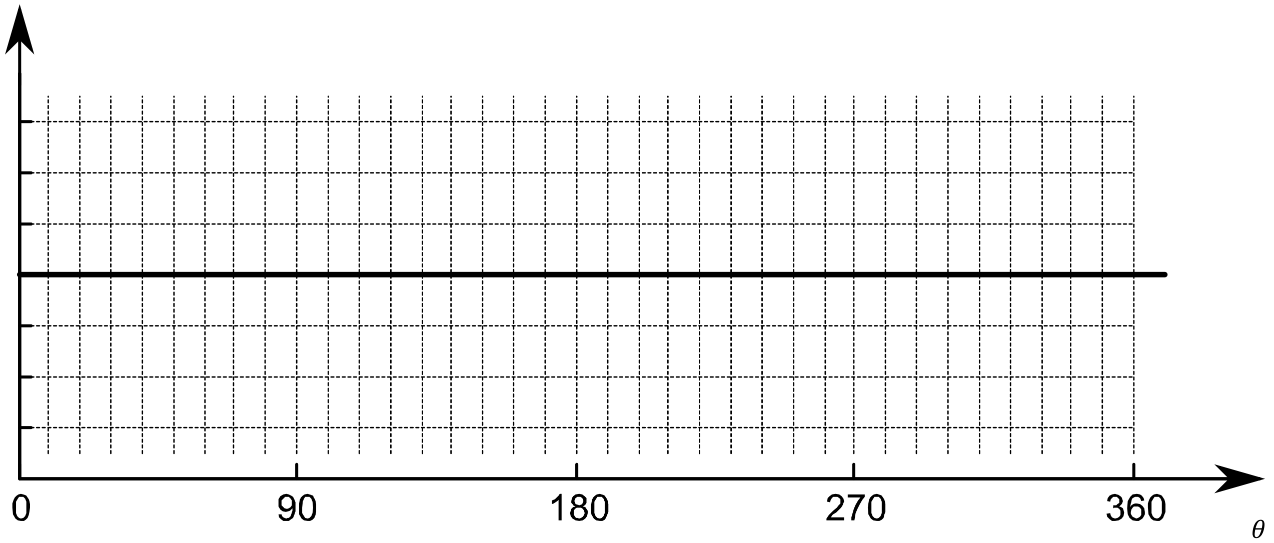


a) Draw the waveform of voltages v_{AGND}, v_{AB}, v_{nGND} and v_{An}.

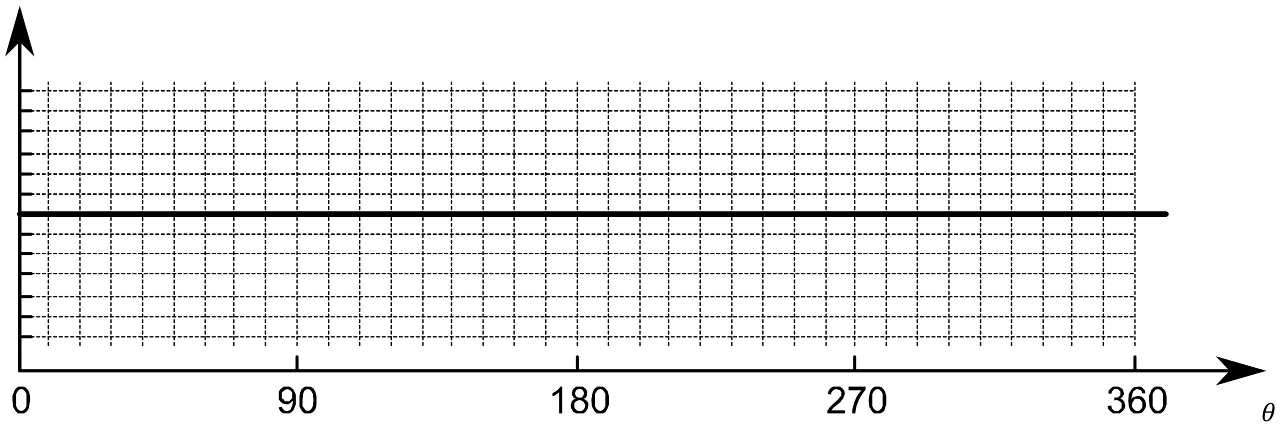
b) Calculate the THD of the phase voltage v_{An}.
Perform the same calculation for the phase voltage v_{An} in Problem 2 in Demonstration 8 (P8-9 in Undeland book).
Compare these two values.

c) Calculate the RMS value and average value of the DC-source currents in phase A.
Compare the RMS value and average value.
Perform the same calculation and comparison for the DC-source current in Problem 2 in demonstration 8 (P8-10 in Undeland book).

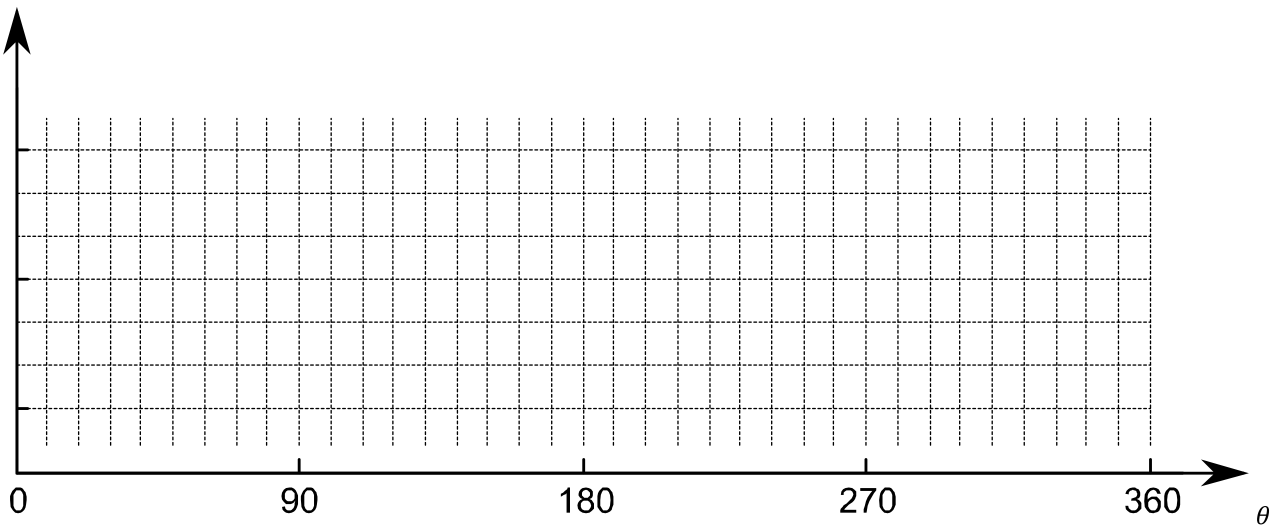
v_{AGND}



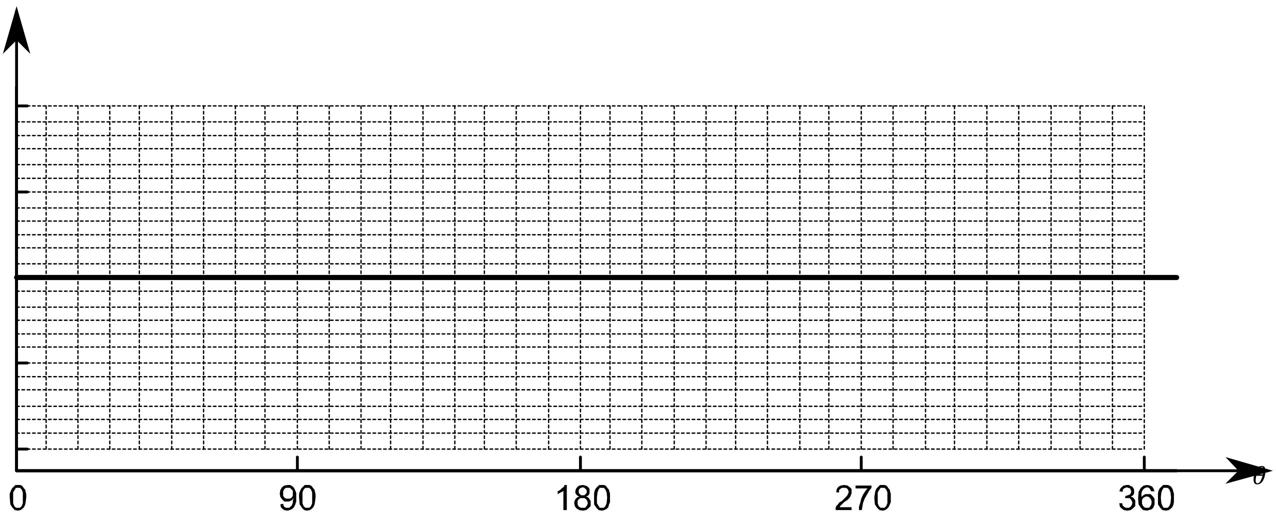
v_{AB}



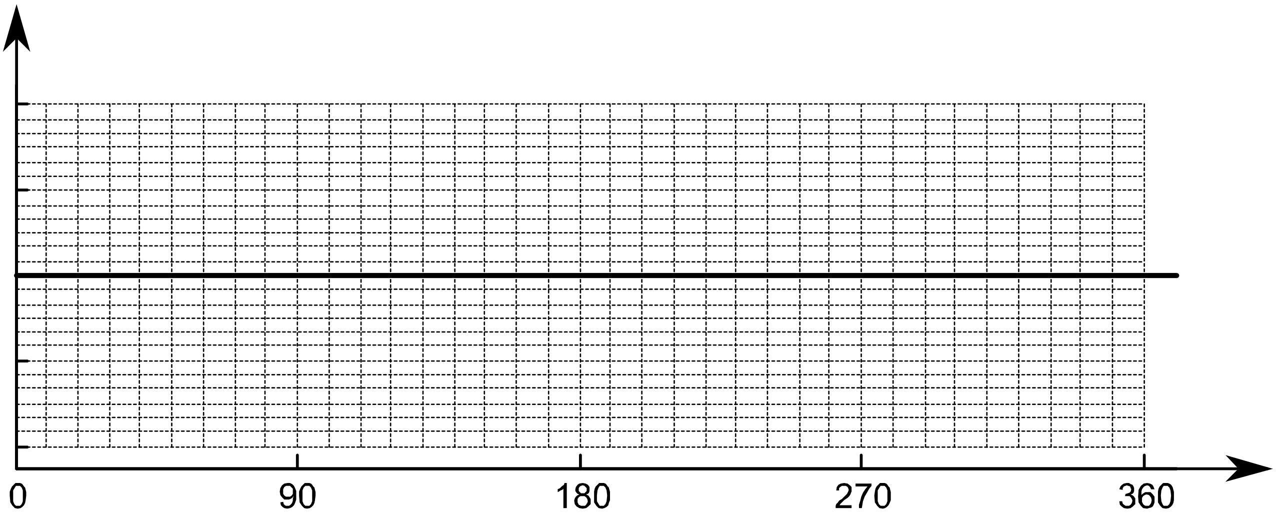
v_{nGND}



v_{An}



i_{An}



Equations used from previous lectures

Fourier analysis

$$g(\theta) = f(t)\,,\ \theta = \omega t$$

$$g(\theta) = \frac{a_0}{2} + \sum_{n=1}^{\infty}\left[a_n \cos(n\theta) + b_n \sin(n\theta)\right]$$

$$a_n = \frac{1}{\pi}\int_{\theta_0}^{\theta_0+2\pi} g(\theta)\cos(n\theta)d\theta \quad n = 0,1,2,3,...$$

$$b_n = \frac{1}{\pi}\int_{\theta_0}^{\theta_0+2\pi} g(\theta)\sin(n\theta)d\theta \quad n = 1,2,3,...$$

Table 3-1 Use of Symmetry in Fourier Analysis

Symmetry	*Condition Required*	a_h and b_h
Even	$f(-t) = f(t)$	$b_h = 0 \quad a_h = \frac{2}{\pi}\int_0^{\pi} f(t)\cos(h\omega t)\,d(\omega t)$
Odd	$f(-t) = -f(t)$	$a_h = 0 \quad b_h = \frac{2}{\pi}\int_0^{\pi} f(t)\sin(h\omega t)\,d(\omega t)$
Half-wave	$f(t) = -f(t + \frac{1}{2}T)$	$a_h = b_h = 0$ for even h; $a_h = \frac{2}{\pi}\int_0^{\pi} f(t)\cos(h\omega t)\,d(\omega t)$ for odd h; $b_h = \frac{2}{\pi}\int_0^{\pi} f(t)\sin(h\omega t)\,d(\omega t)$ for odd h
Even quarter-wave	Even and half-wave	$b_h = 0$ for all h; $a_h = \begin{cases}\frac{4}{\pi}\int_0^{\pi/2} f(t)\cos(h\omega t)\,d(\omega t) & \text{for odd } h\\ 0 & \text{for even } h\end{cases}$
Odd quarter-wave	Odd and half-wave	$a_h = 0$ for all h; $b_h = \begin{cases}\frac{4}{\pi}\int_0^{\pi/2} f(t)\sin(h\omega t)\,d(\omega t) & \text{for odd } h\\ 0 & \text{for even } h\end{cases}$

RMS value of a function

$$F_{rms} = \sqrt{\frac{1}{T}\int_0^T f(t)^2\,dt}$$

Average value of a function

$$F_{avg} = \frac{1}{T}\int_0^T f(t)dt$$

Total harmonic distortion (THD)

$$\%THD = 100\frac{\sqrt{F_{rms}^2 - F_{1,rms}^2}}{F_{1,rms}} = 100\frac{F_{dis}}{F_{1,rms}}$$

Control of the cascaded full bridge inverter (Lecture slides 32)

- A typical modulation scheme is Selective Harmonic Elimination
- All switches operate with the fundamental frequency which gives low losses
- For each module, the switching angle (α) is controlled.